IN THE SPECIFICATION

Please replace paragraph [0001] with the following amended paragraph:

[0001] The present invention relates to a method and system for registering 2D (two-dimensional) radiographic images with images reconstructed from 3D (three-dimensional) scan data. More particularly, the invention relates to a method and system for registering 2D stereo x-ray image~~images~~ data with digitally reconstructed radiographs of 3D CT scan data.

Please replace paragraph [0006] with the following amended paragraph:

[0006] Image-guided radiosurgery requires precise and fast positioning of the target at the treatment time. In practice, the accuracy should be below 1 mm, and the computation time should be on the order of a few seconds. Unfortunately, it is difficult to meet both requirements simultaneously, because of several reasons. First, the two different modality images, i.e. CT scan images and x-ray images, have different spatial resolution and image quality. Generally, x-ray image resolution and quality are superior to the resolution and quality of DRR images. Second, DRR generation relies on a proper attenuation model. Because attenuation is proportional to the mass density~~intensity~~ of the target volume through which the beam passes through, the exact relationship between the traversed mass density~~intensity~~ and the CT image intensity needs to be known, in order to obtain an accurate modeling. Establishing this relationship is difficult, so a~~the~~ linear attenuation model is often used. However, the skeletal structures in DRR images cannot be reconstructed very well using the linear model, the DRRs being only synthetic x-ray projection images. Finally, x-ray images usually have a large image size (512 x 512). For better registration accuracy, it is desirable to use the full resolution image. Full resolution images are rarely used, however, due to the extremely slow computation that results from using such images.

Please replace paragraph [0029] with the following amended paragraph:

[0029] For projection A, given a set of reference DRR images which correspond to different combinations of the two out-of-plane rotations (r_A, ϕ_A) and (r_B, ϕ_B), the 2D in-plane

transformation (X_A, Y_A, ϕ_A) can be estimated by the 2D image comparison. Determining the two out-of-plane rotations ~~(r, θ_B)~~(r_A, ϕ_A) and (r_B, ϕ_B) relies on which reference DRR is used for best similarity match. Similarly, the 2D in-plane transformation (X_B, Y_B, θ_B) and the out-of-plane rotations (r_B, ϕ_B) can be estimated for projection B.

Please replace paragraph [0036] with the following amended paragraph:

[0036] In step 120, the three parameters are rapidly searched using a 3D multi-level matching method (described in connection with FIG. 4 below). A sum of absolute differences method ("SAD"; described in ~~the~~ co-pending~~ ACCL-127 application~~, commonly owned U.S. Patent Application Serial No. 10/652,717, (the " '717 application") entitled "Apparatus And Method For Determining Measure Of Similarity Between Images) is used as the similarity measure. In this step, there is no floating computation. The pixel accuracy for the translations (x,y) and half-degree accuracy for the in-plane rotation (θ) are achieved.

Please replace paragraph [0037] with the following amended paragraph:

[0037] In the next step, i.e. step 130 (phase 2 of the registration process), the two out-of-plane rotations (r, ϕ) are separately searched in one dimension, based on the values of the in-plane parameters (x, y, θ), determined in previous step 120. A plurality N_r and N_ϕ of out-of-plane rotation angles may be determined, respectively, for said rotational parameters (r, ϕ). A plurality $N_r * N_\phi$ of 2D reference images may be generated, one reference image for each of said plurality N_r and N_ϕ of said out-of-plane rotation angles. A more complicated similarity measure, based on pattern intensity (described in the '717~~co-pending ACCL-127~~ application), is used to detect the reference DRR image that corresponds to a combination of two out-of-plane rotations (r, ϕ). The search space for the possible rotation angles is the full search range of out-of-plane rotation angles. For an initial estimate, the full search range is sampled at every one-degree interval. In step 140 (phase 3), the in-plane translation parameters (x, y) are refined using 2D sub-pixel matching. 2D sub-pixel matching is a full range search method. Based on the

updated transformation parameters (x, y, θ, r, ϕ) obtained from the previous step in the registration, a set of DRR images (3 x 3 or 5 x 5) is generated by translating the unknown reference DRR, one sub-pixel at a time. The in-plane translations (x, y) in sub-pixel accuracy are refined by finding the best match between the x-ray image and the DRR images.

Please replace paragraph [0038] with the following amended paragraph:

[0038] In step 150 (phase 4), the in-plane rotation parameter θ is refined using 1 D interpolation, based on the updated values for the in-plane translation parameters (x, y) from step 140, and the updated values of the out-of-plane rotation parameters (r, ϕ) from step 130. In step 160 (phase 5), the out-of-plane rotations are separately refined to a better accuracy using 1 D search, based on the updated values for the in-plane transformation parameters (x, y, θ), from steps 140 and 150. In steps 140, 150, and 160 (phases 3, 4, and 5), a similarity measure method based on pattern intensity (described in the '717~~co-pending ACCL-127~~ application) is used, to ensure higher accuracy.

Please replace paragraph [0040] with the following amended paragraph:

[0040] FIG. 4 illustrates a multi-resolution image representation for the multi-level matching process, used in the first phase (step 120 in FIG. 3) to initially estimate the in-plane transformation parameters. The full-size image is at the bottom (Level 1). The upper images (Level 2, Level 3 and Level 4) have lower spatial resolution. The lower resolution images are obtained by lowe~~r~~ pass filtering, and by sub-sampling of the full-size images.

Please replace paragraph [0045] with the following amended paragraph:

[0045] The controller 208 includes means for generating a set of 2D DRR images of the target, using the 3D scan data from the CT scanner, and using the known location, angle, and intensity of the imaging beam generated by the radiation source. The controller 208 also includes software for determining a set of in-plane transformation parameters (x, y, θ) and out-of-plane rotational parameters (r, ϕ), the parameters representing the difference in the position of

the target as shown in the x-ray image, as compared to the position of the target as shown by the 2D reconstructed images. The software for determining the out-of-plane rotational parameters (r, ϕ) may be configured to determine a plurality N_r and N_ϕ of out-of-plane rotation angles, respectively, for the rotational parameters (r, ϕ). The means for generating a set of 2D DRR images of the target may be configured to generate a plurality $N_r * N_\phi$ of 2D reference images, one reference image for each of the plurality N_r and N_ϕ of the out-of-plane rotation angles.